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SOVIET BLOC INTERNATIONAL
GEOPHYSICAL YEAR INFORMATION
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PLEASE NOTE

This report presents unevaluated information on Soviet Bloc International Geophysical Year activities selected from foreign-language publications as indicated in parentheses. It is published as an aid to United States Government research.

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I. GENERAL

Soviet IGY Chairman Discusses IGY Progress

In connection with the conclusion of the first half of the IGY on 1 April, the editors of Izvestiya requested I. P. Bardin, chairman of the Soviet IGY Committee to comment on some of the results of work already conducted and on those tasks which still remain for scientists to engage in during the latter half of the IGY.

Bardin noted that a characteristic feature of the IGY is the fact that it has brought scientists of many specialties closer together -- scientists who previously have had little relationship with one another. Taking part in the IGY are meteorologists, astronomers, glaciologists, oceanologists, and specialists in the field of terrestrial magnetism, ionospheric physics, seismology, gravimetry, and many others.

It should be especially emphasized, says Bardin, that the IGY is a clear example of wide international scientific cooperation which is strengthening cultural relations between countries.

Discussing the Soviet Union's part in the IGY, Bardin reports the following:

In number of observation stations and volume of expeditionary works the USSR is the biggest participant in the IGY. As is known, the launching of the first Soviet artificial Earth satellites was the beginning of a new era in man's knowledge of the cosmos. Our country is making a great contribution in 11 other fields of IGY investigations. Preparations for the work under the IGY program were made in nearly 100 scientific institutions of the USSR in a short period of time.

Of the 496 stations and observatories now working on the program, 200 were newly organized or were completely re-equipped in connection with the IGY. Visual observations of artificial Earth satellites are being provided by 66 special stations. Hundreds of stations are working on observations of aurora and noctilucent clouds. In preparing for the IGY, 30 types of instruments and equipment of new design and 400 types of apparatus and materials of current manufacture were supplied to scientific institutions by Soviet industry. The USSR organized a mighty Antarctic expedition. Twelve large Soviet oceanographic ships have been assigned to work in all oceans of the world according to an itinerary agreed on with other countries. Investigations of the transition zone between the continents and ocean in the region of the Kurile-Kamchatka Trench and many other investigations are being conducted on a broad scale. According to the IGY program, joint expeditions with scientists of the German Democratic Republic, Czechoslovakia, and the United Arab

Republic have been organized and are being planned for the future. Meteorological specialists are exchanged in the Antarctic with the US and a number of other tasks are also participated in with foreign scientists.

Such a scope of participation of Soviet scientific institutions in the IVY became possible thanks to the daily aid from the party and government, which, in every way possible, supported measures for the future development of science and the strengthening of international scientific cooperation for peaceful purposes.

In speaking of some of the preliminary scientific results, we should, in the first instance, recall the geophysical investigations with the aid of artificial satellites and rockets. These results were recently published in the central press and are of great interest for geophysicists the world over.

The work in the Antarctic led to important changes in our ideas on the sixth continent. Many now regard the Antarctic as a group of islands covered by an ice cap. Measurements of the thickness of the ice, made by Soviet, British, and US explorers have established the fact that the average thickness of ice is not 1 1/2 kilometers, as previously supposed, but, evidently, around 2 1/2 kilometers. Accordingly, the data on the total volume of ice in the Antarctic, which has great scientific and practical significance, was changed.

Soviet oceanographic expeditions also have made a number of discoveries. For example, it is discovered that the Kuroshio warm current was displaced to the north by 300-400 km. In the region of the Mariana Islands, a record ocean depth of 10,960 meters was found.

Corrections to existing magnetic charts are being made on the basis of measurements made by the Zarya, the Soviet nonmagnetic ship, which is the only one of its kind in the world. The Zarya has already conducted work in the Baltic Sea and the Atlantic Ocean.

Great successes have been achieved by explorers of the Fedchenko Glacier in the Pamirs, by the associates of the drift stations in the North Pole and the stationary stations in the Arctic, which are equipped with instruments for photographing the aurorae, sounding the ionosphere, and measuring cosmic radiation.

However, the over-all scientific results of observations can be summed up only after work on the unique data which will be obtained from all over the world. These data will present the possibility of obtaining a more or less correct chart of all basic geophysical processes occurring on a world scale. Therefore, even now, the order of collection, storage, and dissemination of these materials is being regulated by international organizations.

In the USSR and US there are universal world centers to which the IGY committees of all countries should provide a flow of materials according to all program investigations. Each of these centers will have a complete set of materials and, in necessary cases, will transmit to each other missing data of observations.

In the USSR, the responsibility for creating such a world center falls on three departments: The Main Administration of the Hydrometeorological Service under the Council of Ministers USSR (Scientific Research Institute of Aeroclimatology), the Ministry of Communications USSR (Scientific Research Institute of Terrestrial Magnetism, Ionosphere, and Radio-wave Propagation), and the Academy of Sciences USSR. Many functions of the center are now being accomplished and data, both from Soviet and foreign scientific institutions, have already begun to arrive at the center. In future months in Moscow, on Lenin Hills, a special building will be equipped where the center can discharge all of its functions including acquainting Soviet and foreign scientists with materials which it has. In this building, in particular, there will be suitable reading rooms equipped with apparatus for reading microfilms and other instruments for facilitating the study of IGY data. Here, also, conditions will be created for making the necessary computations. The laboratories of the center and organizations connected with them will microfilm and duplicate for a minimum price the materials stored in the center so that interested scientists can work not only on the premises of the center but at the place of their work, regardless of where it might be; for example, in Khabarovsk or far beyond the boundaries of the Soviet Union.

Even now, Soviet scientists must seriously think about organizing the processing of IGY materials and starting the appropriate scientific research work. In the very near future state importance should be attached to these problems because without proper organization of such investigations the efforts and money spent on accomplishing the program of observations will not be realized. We should strengthen the number of scientific institutions and charge them with fundamental tasks in this area. At present, we should boldly examine the program of geophysical and certain other institutions from the viewpoint of the necessity of enlisting qualified specialists to work on IGY materials.

Processing of IGY materials and the correct formulation of tasks which must be solved with the aid of these materials has already become an extremely real problem, even in other countries. The possibility of wide cooperation between countries should not be excluded, even after the final stage of the IGY.

The Fifth Assembly of Special Committee for the IGY (CSAGI) will be held in Moscow from 29 July to 9 August 1958. Around 300 foreign delegates and guests will attend. Special attention will be given to concrete forms of cooperation between scientific

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Institutions of different countries in the course of processing the most valuable materials anticipated as a result of the IGY and also the activity of world centers. It is proposed to examine the role of existing international scientific unions and others in the coordination of IGY data processing. In this matter, it is intended that that which is new and which the IGY has introduced into international scientific cooperation should not only be taken into account but should also be developed.

The assembly has been designated to determine the future fate of the central organs of the IGY and to resolve a number of questions on future cooperation. In particular, the possibility that in a number of areas of investigation the period of observations under the IGY program will be extended has not been excluded. Many scientists have already expressed such a desire, referring to the fact that, for example, works at certain stations were not begun on time or that in separate types of investigations, it is necessary to realize more fully efforts already lost in preparing for observations.

The assembly will examine the problem of protecting the interests of countries and individual scientists in using IGY materials and will decide on certain organizational and special problems.

The Soviet IGY Committee hopes that this assembly will be a future stride in strengthening international scientific cooperation already begun during the preparation and conduct of the IGY and will be a major event in scientific life. (Moscow, Izvestiya, 2 Apr 58)

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IGY World Data Center B Described

A. D. Nikolayev, writing in a Soviet historical archives journal, presents the following information on IGY World Data Center B:

At the Barcelona Conference, in September 1956 it was decided to create three IGY World Data Centers; one each in the USSR and the USA, and a third center which will consist of several sections located in various countries.

In the USSR, the center is being created in Novosibirsk where a special building will be constructed during 1957. Each center should have a central catalog of all materials which will be stored at the center. Data of IGY observations and reference material should be available to the national IGY committee of any country and all interested national and international organizations. Each center should supply on request copies of data received for storage at a price not exceeding the cost of duplication and transmittal of the required data.

Each country itself decides to which center it will send materials of observations, and that center is responsible for sending copies of these materials to the other two centers.

In the USSR, the center will consist of four basic complexes: (1) scientific divisions engaging in the development and generalization of the collected material; (2) a machine records center which makes the required computations with the aid of card sorting machines; (3) a photographic laboratory and printing shop; and (4) an archives repository as a place for collection and storage of materials, their registration and organization for daily use within the center and on exchange.

At the center, it is intended to store materials of observations in the following form:

1. Primary material (being processed) reduced to tables, according to each station for a specified chronological segment of time (month, year), and individually by each type of observations. Tables will be received at the center from institutions carrying out primary processing of observation materials. In the USSR, such institutions are scientific research institutes, territorial administrations of the hydrometeorological service and observatories. Registration of observation materials will be made according to territorial designation and within the territorial unit according to each observation point (station, post, observatory).

In the future, for more rapid obtaining of the necessary number of copies (for exchange) all tables will be microfilmed and the tables themselves will be arranged in storage units, according to subject, geographic and chronological designation.

For storing tabular material, the usual archive shelving with movable shelves are required.

2. Photocopies and microfilm copies obtained by photographing tabular material and the center itself.

- a. Photocopies will be made for exchange on order of institutions and individual researchers, for making punched cards in the center itself, by direct photoreproduction of the original, or by means of obtaining an enlarged positive reprint from a microfilm negative. This type applies to material which will be stored for a short period.

- b. Microfilm copies are supposed to be stored in the following form:

- (1) Negatives in the original

(2) Second negatives, or contactypes, for fast preparation of required number of positives ordered by other city organizations, for work with them in the reading rooms of the center and for forwarding the required number to the Scientific Research Institute of Aeroclimatology (NILAK) (all materials stored in the center in the form of microfilm copies should be in Moscow in NILAK).

(3) Positives for daily work in the center.

3. The third group, which is very extensive in respect to the space occupied, consists of punched cards, to which will be transferred data from the table by means of perforations on special cards (with the aid of these punched cards data of observations are put into the machine, which makes the required calculations). Punched cards make it possible to shorten considerably the time for processing IQY observations and their duplication. By volume, they take up approximately three fourths of the entire storage area. Here, registration acquires a special significance because, besides information on the points and the periods the punched cards apply, it is necessary to know the exact control numbers for each point, not only for the entire period, but also for each year and each month, for each period of observations and according to each model. (The center will have computers operating with 80-column punched cards. Each column of a punched card (or several columns) consolidate individual elements of observations (temperature, moisture, pressure, precipitation etc.). A sample of a punched card with consolidation of specified columns is called a model. For each type of observation (meteorology, aerology, agrometeorology, etc.), there can be one or several independent models.) Without these numbers, control of the operation of the machine cannot be accomplished.

To date the compilation of reduced schedules and the delivery of data from them to the catalogue was made by hand from control tabulating charts or working orders of the machine records center; that is, the monthly figures from each station were written out, and the necessary calculations were made. After receipt of the punched card in the archives, these same data were rewritten on the registry cards of the archives, etc. All of this copying was not without errors.

At present, in the Scientific Research Institute of Aeroclimatology, experiments on mechanizing this process are being conducted. A mechanized method of registry excludes all manual copying, and consequently, the errors which occur during copying. After implementation of this method, experimental works may be conducted on transferring data of subject catalogues, named cards, bibliographies, etc; to punched cards. Punched cards are stored on shelves (50 boxes per shelf). Existing samples of boxes do not provide the necessary conciseness during storage. New boxes in which punched cards will be placed in a compressed state are contemplated for the center.

Punched cards may be used not only for conducting the necessary working out of this or that theme within the center at the machine records center, but also for exchange. The point is that in passing punched cards through the tabulator (a tabulator is a basic machine in the complex of card-sorting machines performing the required calculations), the tabulator not only performs the necessary calculations, but also simultaneously prints the data from the punched cards and the results of the operation on paper (tabulating sheets or special forms). For example, in 8 hours one tabulator can print meteorological data taken from tables for a post for approximately an 11-year period, while, in the same time, manual copying of these tables would require 300 hours.

Therefore, it is apparent that it is planned to concentrate in the center a large volume of very important material of scientific significance which, undoubtedly, should not lie dead. This material will be widely used not only by the center itself, but also by all kinds of scientific research, design, and other institutions.

For working with the materials in the center, several reading rooms with a total area of over 100 square meters including a special room for working with microfilms equipped with apparatus for reading from the roll and clips, will be opened.

To create a normal regime for storing materials in the repositories, installations for air conditioning are contemplated. For transporting materials from repositories to the reading rooms, the workshop of the machine records center contemplates a lift and special cart for return. (Istoricheskiy Arkhiv, No 2, Mar Apr 57, pp 219-221)

The Photon Rocket in Space Travel

The fantastic speeds necessary for space ships for interplanetary travel are obtainable by using so-called photon rockets.

I. I. Drakin, Docent, of the Moscow Aviation Institute, when interviewed by N. Posysayev, had this to say on the subject.

Drakin recalled the experiment of the famous Russian physicist, P. N. Lebedev, who, in 1899, discovered the action of light on a solid body and later, in 1909, on a gas.

Lebedev's experiments showed that light and a material body have one property in common, mass. According to the quantum theory, light is radiated and absorbed by the atoms and molecules of a substance, not by a continuous flow but by discrete portions, quanta. These portions are the so-called photons, which are the material particles of light. It is possible to use the force of the pressure of photons in the motors of interplanetary ships.

Thermonuclear reactions arising in a nuclear accelerator create powerful beams of photons. The photons obtained by such means will be directed on large reflectors. Falling on the reflectors and reflected from them, they exert a pressure which also serves as the moving force necessary for the acceleration of the rocket's flight. The thermonuclear reaction must take place outside the rocket since otherwise the material of the rocket could not withstand those temperatures which are the result of the reaction. It is apparent that the reaction must take place in the focus of the reflector. The brilliance of the photons obtained from this source will be so bright that the rocket will be able to be seen from the Earth at a very great distance.

Not all of the photons will be reflected by the reflector. Part of them will be absorbed by its material. But even this small part is sufficient to greatly heat and even melt the reflector. To avoid this, it is necessary to ensure the least possible amount of absorption of photons by the reflecting surface. A special material must be used. One which has a high coefficient of reflection, for example, silver. Great importance is attached to the cooling of the reflector in photon rockets during flight. Cooling can be accomplished by using a liquid, easily-fusible metal such as sodium, and also by using mercury or water. An electric generating unit can be operated by the heat energy conducted from the reflector.

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The weight of the photon rocket will vary from several hundred to several thousand tons, depending on its purpose.

In returning to Earth or in landing on another planet, the rocket must be turned end for end so that braking may be effected by the same photon motor. Landing can be accomplished by means of dropping a detachable cockpit by parachute or by gliding, using wings. In the latter case an empennage must be provided.

The cone shape of this interplanetary ship will facilitate the problem of danger from meteorites. Actually, as a result of its own enormous speed, the rocket will always encounter meteorites, traveling at speeds of thousands of kilometers an hour, only with its nose section, and this at a very small angle of attack, which causes the meteorites to ricochet and not penetrate into the ship. The detection of meteors can be effected by radar. A battery of rocket motors must be provided inside the rocket to deflect its course from meteors. Communication with the rocket and tracking will be done by radio.

The most important problems connected with a photon rocket are the achievement of a low structural weight and a low fuel consumption. In chemical rockets, the fuel load comprises 70-80 percent of the rocket's total flight weight. In the photon rocket, the weight of the fuel will be less, but the weight of the reactor itself will be large. Thus, one of the chief problems in the development of the photon rocket will be the building of a low-weight reactor of tremendous power. In contrast to chemical rockets, the photon rocket motor will operate during the entire flight.

The great speed of this interplanetary ship will make short-duration flights to planets possible. For instance, a flight to Mars and return will require 4-5 days.

The photon rocket will find use only for flights beyond the atmosphere. For flights in the atmosphere, the usual rockets using chemical or atomic fuels will be used.

The possibility of building a photon rocket was enhanced after the harnessing of atomic energy and the launching of the first Soviet artificial Earth satellite.

At present, the problem of the photon rocket is in its initial stage. Substantial progress in the field of designing the rockets depends on the development of a low-weight, continuously operating reactor. (Moscow, Trud, 19 Jan 58)

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The last stages of a satellite's existence are of great scientific interest as they are analogous to meteorites and meteors when they are subjected to the intense braking action of the atmosphere. V. Krasovskiy and D. Okhotsimskiy present this analogy in the Pravda article, "The Upper Atmosphere and Artificial Earth Satellites," along with a discussion of the effects produced during the flight of meteors, meteorites, and satellites through the atmosphere.

Heating, illumination, and ionization of the atmosphere about a meteor or meteorite are the results of a generally complex process. Impacting molecules or atoms of the atmosphere are partially deflected from the rapidly moving body and acquire great kinetic energy, which results in the above phenomena. When the free flight path length of the reflected particle becomes comparable to the cross section dimensions of a meteoritic body, a compressed air "cap" forms in front of it, attaining a temperature of several thousand degrees. This usually occurs in the burning region of meteors at an altitude of 70 to 100 kilometers. In the case of very large bodies, this process can begin at a considerably higher altitude.

Fine protuberances on meteors or meteorites rapidly vaporize because of the temperature of the "cap." Such a process can be duplicated by placing a similar type object in a similar type object in a high temperature furnace. It will be observed that the fine projections on the surface incandesce before the main body of the object has even reached a high temperature. Further heating results in incandescence of the meteor or meteorite body and subsequent violent evaporation of its substance.

In the high layers of the atmosphere, where a considerable portion of the atmosphere consists of atoms, union of the atoms into molecules occurs on the surface of the meteor or meteorite. This results in supplementary illumination at an altitude of 150 to 200 kilometers. This illumination is very weak, however, and can only be observed in the case of a body with large dimensions and on a clear, dark, moonless night.

Molecules atomized along the path of a meteor liberate many free electrons which not only leave a trail visible to the naked eye or by special optical instruments, but also reflect radio waves, permitting their observation at night, during the day, or in cloudy weather by means of radar. At present, cases of meteor trails at altitudes up to 200 kilometers have been registered. However, the majority of them have been observed in the more dense layers of the atmosphere, at altitudes from 70 to 100 kilometers.

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Results of the latest investigations of meteors showed that about 1/1,000 or 1/10,000 of the kinetic energy of the meteor is consumed in the formation of light and ions. This is true in cases of both fast and slow meteors. Cases of meteors with velocities of 8 kilometers per second have been registered. In these cases the meteors lost a considerable portion of their initial energy on entrance into the atmosphere and had a velocity approximately that of an artificial satellite.

Observations of the movements of satellites by radio and optical methods established that atmospheric braking was considerably greater than had been expected on the basis of available data on atmospheric density. This can be explained by the fact that the actual values of atmospheric density at the perigee level exceed those obtained by contemporary methods.

As the orbit of a satellite tightens, the braking of the satellite becomes more intense, and its rate of descent progressively increases. Accordingly, in the movement of a satellite from an altitude of 150 to 160 kilometers to its complete disintegration in the dense layers of the atmosphere, only one to two revolutions occur. The shorter period of revolution for the rocket carrier of the first satellite is explained by the fact that its weight to cross section area (so-called cross-section loading) ratio was smaller than that for the satellite.

Effects caused by satellites which have a body with large mass and density, in comparison with meteors, are similar to those caused by meteorites. Thus, in the last stages of a satellite's life, it is possible to expect effects analogous to those observed during the fall of meteorites. As the body of the first satellite was made of aluminum alloy, it should have disintegrated and vaporized more quickly than the dense, difficult to fuse meteorite bodies. As the last stage of the first satellite's life was extremely short, and since it flew over uninhabited areas and was unobservable at times because of clouds, information on it was extremely limited. However, it can be expected that in the observations of the second and future satellites, it will be possible to investigate the effects in the last period of their existence more in detail.

The authors say that artificial satellites are an important means for investigation of the upper atmosphere but more detailed information is required for improvement in accuracy of observations. Observation of the burning of satellites will make it possible to better analyze meteor effects and use them for supplementary information on the upper atmosphere. Also, valuable material for the study of the properties of the atmosphere can be obtained from information on the audibility of satellite radio signals. (Moscow, Pravda, 21 Mar 58)

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Laws governing the Motion of an Artificial Satellite

The laws governing the motion of an artificial Earth satellite are presented in an article by Professor Yu. A. Pobedonostsev of the Moscow Aviation Institute imeni Sergo Ordzhonikidze. (Priroda, Jan 1958)

[Note: The Pobedonostsev article covers approximately the same ground as the Appendix section of his pamphlet, Iskusstvenny Sputnik Zemli (Artificial Earth Satellite), Moscow, 1957. A translation of the Appendix has been published by the US Joint Publications Research Service as JPRS/NY-263.]

Soviets Plan Venus Rocket Between 1962-1967

Soviet scientist Khlebtsevich has announced that the USSR will launch a rocket to Venus between 1962 and 1967.

According to plans, the five-stage rocket will have a takeoff weight of 250 tons. (Budapest, Repules, No 3, Mar 58, p 13)

Rhenium as Nose Coating for Rockets

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In an article dealing with special materials used in the construction of rockets, the author says, "...the melting point of rhenium is 3170 C. It is almost wholly insensitive to oxygen. Since it is more costly than gold, it is used only to coat the rocket nose." -Lajos Ocsovai (Budapest, Repules, No 3, Mar 58, p 17)

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Lhasa Station Receives Signals of Satellite I

On 12 October 1957, at 0847 hours, the first Earth satellite of USSR passed over Lhasa. Both the Lhasa Posts and Telecommunications Bureau and the radio station of Tibet Jih-pao received signals transmitted by the satellite. Observation of the earth satellite was also made by the Lhasa meteorological chan (post) and the Lhasa Geophysical Observatory of the Academia Sinica. (Lhasa, Tibet Jih-pao, 13 Oct 57, p 1).

III. GEOMAGNETISM

Short Period Perturbations of the Earth's Electromagnetic Field

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The results of an analysis of short period oscillations of the Earth's electromagnetic field, with periods averaging from 5 up to 180 seconds, are presented in an article entitled "Short Period Disturbances of the Earth's Magnetic Field," by V. A. Troitskaya, scientific secretary for the Soviet IGY Committee.

The use of recordings of Earth currents in large scannings (90 mm per hour and one mm per second), recordings of Earth currents in different widely separated points, and highly sensitive recordings of the magnetic field on fluxmeter equipment developed by A. G. Kalashnikov made it possible to establish a number of regularities and characteristics of short period oscillations.

A criterion for a distinct oscillatory cycle for the observed oscillations was established on the basis of the classification of the pulsations. This division revealed two groups of oscillations: steady oscillations, continuing as a rule for several hours, and train-type oscillations, representing their own distinct group of oscillations. Both types of oscillations have clear daily variations according to universal time, and are characterized by different ranges of the values of the periods and amplitudes of the oscillations, which are connected with the different complex disturbances of the Earth's electromagnetic field.

The time of origin of the two types of oscillation (different according to their properties), the regularity of their perturbations day in and day out, and the regularity of their daily variation show that the ~~excitation of these oscillations is connected with the orientation of~~

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the Earth's north and south magnetic poles relative to the sun. (Trudy Geofizicheskogo Instituta AN SSSR, No 32 [159], 1956, pp 26-61)

Ob' Voyages In South Pacific and Tasmanian Sea

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Autumnal storms have plagued the Ob' in the course of 3,000 miles of voyaging in the 40th and 50th latitudes since leaving the Australian port of Adelaide. Despite these difficulties, V. Takachev, first mate, reports that many complex observations were completed at 25 oceanographic stations in the Tasmanian Sea and the Pacific Ocean.

Geologists are making measurements of the depths and take soil probes from the ocean's bottom. The soil taken at one of these stations revealed the presence of manganese ore. Workers of the aerometeorological detachment conduct work on studies of solar radiation and other problems. Much that is new is being learned by geophysicists studying gravity and the Earth's magnetic field. Biologists study the animal and plant worlds of the ocean's depths. For the first time, trawling with a variable-depth depressor trawl, the newest instrument for catching deep-water life was successfully accomplished in the southern hemisphere. More than 100 different kinds of fish, squid, and other inhabitants of the ocean were obtained. Large deep-water eels with strongly elongated jaws, bit Chauli-odi with saberlike teeth, and luminescent anchovies were caught. Snout-fish with special organs of illumination and telescopic eyes which appear to be unique were found. The detailed processing of this catch from the South Tasmanian Sea enriches science much more than the number of types discovered here for the first time.

The expedition's weather forecaster, Prof V. M. Shapayev of the Leningrad Hydrometeorological Institute, compiled on maps the information ~~received by radio from the different meteorological stations in the southern hemisphere.~~ On 23 March the Ob' crossed the 70th parallel. (Moscow, Izvestiya, 26 Mar 58)

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V. ARCTIC AND ANTARCTIC

Arctic Atmosphere Studies

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"Atmospheric Process in the Central Arctic," an article by S. S. Gaygerov, Candidate of Geographical Sciences, Aerological Detachment of Drift Station Severnyy Polyus-4 gives the following information.

At the time of the Soviet high-latitude expeditions of 1948 and 1959, aerological observations were organized on drifting ice. The station Severnyy Polyus-2 conducted regular aerological observations from April to October 1950. The stations Severnyy Polyus-3 and Severnyy Polyus-4 conducted a complete cycle of aerological observations from April 1943 to April 1955. In April 1955, the author of this article joined the staff of Severnyy Polyus-4.

The program of aerological observations at the drift station included the use of radiosondes and pilot balloons. During the period April 1955-April 1956, data were obtained on wind conditions at high altitudes. The aerological observations at drift stations included the study of the special structure of the atmosphere in the Central Arctic. One of the characteristic phenomena in the Arctic is the inversion in the lower one-to 2-kilometer layer of the atmosphere. The program of observations also included the study of fluctuations of the altitude of the lower cloud limit by means of frequent launching of pilot balloons and a study of the thermal conditions of the atmosphere by frequent, i.e., four-times-daily, launchings of radiosondes. In one year, the most significant average and maximum heights of radiosonde ascents were achieved. Of particular interest in the work of the aerologists were the results of observations at considerable altitudes, i.e., in the tropopause and stratosphere.

The following is a discussion of some of the preliminary results of the work conducted at Severnyy Polyus-4.

During the period of 1955-1956, the station Severnyy Polyus-4 drifted in the central part of the Arctic Ocean on a very irregular course. The ice moved mainly in the direction of the wind, with a slight deviation to the right caused by the deviating force of the Earth's rotation. The curve of the drift is to a certain extent the resulting characteristic of atmospheric processes. The winding course of the curve indicated a nonstationary nature of atmospheric processes in the region of the drift. Actually, the station area was frequently under the influence of passing cyclones.

Most frequently these cyclones moved from the southwest, i.e., from the archipelago of Novosibirskiye Ostrova, or from the regions of the Arctic bordering on the Atlantic. During the fall, after the Severnyy Polyus-4 ice floe had moved north to 84 degrees N, the number of cyclones decreased. During this period, the atmospheric front separating the arctic air was shifted to more southern latitudes, and the cyclones passed further south. The area of the station was frequently on the periphery of baric formations, and the curve of the drift became less winding. In the winter, the nonstationary nature of atmospheric processes was more evident. Cyclones were especially frequent in the middle of the winter, when they moved in one after another from Greenland and from the North Atlantic into the Central Arctic.

Since the famous drift of the station Severnyy Polyus-1 in 1937-1938, it was definitely known that cyclones, accompanied by strong winds, snowfalls, and blizzards, also frequent the Central Arctic. It is also known that in the central part of the Arctic cyclones occur only half as often as on the coasts of the marginal seas. However, until recently nothing was known about the vertical structure of the cyclones and atmospheric fronts in this area.

The cyclones observed in the area of the pole of inaccessibility in the summer of 1955 were occluded, i.e., the warm air in them was forced up to considerable altitudes. The cyclones, as a rule, were regenerated, i.e., they acquired new life by absorbing cold arctic air; in the more southern latitudes greater temperature contrasts appeared which were necessary for the development of cyclones. The area of the station Severnyy Polyus-4 was frequented mostly by old cyclones with diffused fronts, which did not have any large cloud systems and extensive precipitation zones. However, in a number of cases, during the warm season of the year, cyclones with great temperature contrasts, strong winds, clearly defined fronts, large cloud systems, and extensive zones of precipitation moved in from the southern latitudes.

During the passage of almost every cyclone, one could discover on a vertical cross section a system of an occluded front, bordering on the warm air which was forced to a considerable altitude. The occluded fronts were frequently at a very high altitude, as high as the tropopause. In addition, in almost every case an arctic front system was found in the cyclones, which bordered on the coldest air mass. Sometimes these frontal divisions merged, forming large complex zones.

During the daylight season of the year, the area of Severnyy Polyus-4 was frequently under the influence of anticyclones. The weather conditions in high-pressure areas, i.e., anticyclones, are greatly dependent on the moisture content of the lower air layer. In the winter and spring, at low air temperatures, there was little ice-free water in the ocean, and not enough moisture resulted from evaporation for the formation of clouds and fog. From the south, where the cold, snow-covered continent was located, no warm and humid air was moving northward. Therefore, the weather was mostly clear with good visibility. In mid-June and July, when large puddles of melt water appeared on the surface of the ice and the area of water openings increased considerably, evaporation from the whole ocean surface increased, and more warm and humid air moved in from the south. In the summer, clear weather in the anticyclones was very rare; fog and clouds became more frequent. During April, there were only 3 days with fog; in May, 7 days; in June and July, 21 days each; and in August, 27 days.

The staff at Severnyy Polyus-4 gained the impression that all significant cyclones and anticyclones were high baric formations, which extended at least as far as the level of the 100-millibar isobaric surface.

In the winter, cloudless weather prevailed in the Central Arctic, as opposed to the warm season of the year; all instances of cloudy weather with snowfall and blizzards were caused by cyclones. As suggested by V. Yu. Vize, the beginning of winter in the Arctic is considered to be the moment when the amount of cloudiness decreases sharply, which usually occurs in the Central Arctic in early October. However, in 1955, October in the drift area of Severnyy Polyus-4 was cloudy, and increased cyclonic activity was observed. High-pressure areas and clear weather prevailed in November and December. In mid-winter, especially in February, very intense cyclonic activity developed.

During the period from 30 January to 11 February, seven cyclonic formations passed through the area of Severnyy Polyus-4, mostly intensive and high formations. This unusual cyclonic activity was explained by anomalous atmospheric processes of mid-winter. As a result of intruding arctic air and formation of high-pressure areas in the greater part of the European USSR and Central Europe, and also because of the development of anticyclones and their extensions over the marginal seas, the components of the motion of cyclones developing in the North Atlantic were received farther north than usual. Therefore, contrary to the usual condition, the maximum cyclonic activity in mid-winter occurred in the center of the Arctic Ocean, and the minimum activity was over the marginal seas. Increased cyclonic activity was also observed during March.

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Intensive cyclonic formations during the cold season developed on fronts of great vertical power. As in the summer, they often reached the tropopause, which is apparently normal for these regions. In the center of the Arctic the temperature contrasts between the warm air masses intruding with the cyclone system from southern latitudes, and the arctic air masses which have their greatest vertical power in this region, also exist in the upper troposphere. Frequently, a stormy regeneration of old cyclones takes place, after they have moved in from the temperate zone. In addition, a regeneration of cyclones on the arctic front was observed in the areas adjacent to the Atlantic Ocean.

During the winter, of course, low-intensity cyclonic formations were also encountered, which developed on atmospheric fronts of limited vertical extension, i.e., up to 4-5 kilometers.

The most interesting results were obtained from observations at considerable altitudes, i.e., in the tropopause and stratosphere. In the Central Arctic, the height of the transition zone between the troposphere and the stratosphere, i.e., tropopause, varies considerably with the passage of cyclones, as in the temperate zone. At the front of a cyclone, where warm air is carried out, the tropopause rises, and in the center and rear of the cyclone, where cold air enters, the tropopause is lowered. With the passage of anticyclones, the variations in the height of the tropopause occur in reverse order and are less abrupt.

During the warm season, the tropopause in the Central Arctic is usually higher than in the winter, but the seasonal variations in height are apparently not very great. The maximum height of the tropopause over Severnyy Polyus-4 during the daylight period of 1955 was 11,320 meters at a temperature of minus 55.2 degrees C; it was recorded on 7 July at 0400 hours, under conditions of a strong, warm air flow from the west, encompassing the whole tropopause.

However, the annual maximum heights during the whole period of observations occurred in the winter. Thus, in the northwest part of the anticyclone, on 21 January 1956, the tropopause was at a height of more than 12 kilometers with a temperature of minus 64 degrees C.

The lowest height, at a level of 4,260 meters and with a temperature of minus 37.7 degrees C, was recorded on 27 September in the system of an old cyclone, which had retained great intensity at considerable altitudes.

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The scientists at Severnyy Polyus-4 gained the impression that the height of the tropopause is governed mainly by dynamic causes, connected with vertical movements of cyclonic activity, or with a horizontal transfer from adjoining regions. Apparently, the height of the tropopause is caused less by the temperature regime of the atmosphere, which has strong seasonal variations in the polar countries.

During the whole warm season of the year, i.e., from May to August, the tropopause represented a clearly defined inversion: the temperature ceased to drop with height and began to rise abruptly. Sometimes, usually in the case of a greatly lowered tropopause in cyclones, an isotherm was observed. A complex type of tropopause, consisting of two or more isothermal layers, was observed very rarely and only in the fall.

The depth of the tropopause is frequently about one kilometer although in individual cases it reaches 2-2.5 kilometers. When the tropopause is lowered because of passing cyclones, its depth is increased. As far as can be observed, when the tropopause reaches high altitudes it loses in depth and there is an increase in stratospheric inversion.

In the winter, the temperature drop in the tropopause slowed down with height (less than 2 degrees per kilometer of ascent), or an isotherm took place.

Instances of "disappearance" of the tropopause, as were observed during the cold season at Severnyy Polyus-4 and also at Severnyy Polyus-5, have not been encountered in middle latitudes. As far as is known, an atmospheric stratification of this kind has also been observed in the Antarctic.

Changes in the thermal regime of the atmosphere are closely connected with the nature of its radiation regime. The distribution of temperature with height appears to be most noticeable in the lower part of the polar stratosphere; the distribution changes in accordance with changes in the height of the Sun.

During the warm season, a gradual increase in temperature was observed in the lower stratosphere, or sometimes a stable condition, alternating with an increase in temperature. At heights of about 30 kilometers or more, the temperature rose considerably. Thus, on 7 July 0400 hours, a temperature of minus 21.2 degrees C was recorded at a height of 31,500 meters. The maximum temperature in the lower stratosphere, minus 16.4 degrees C, was recorded on 30 June.

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lower stratosphere. Early in October, instances of falling temperatures in the lower stratosphere have been observed; in late September such a distribution of temperature with height becomes prevalent. After 30 November 1955, Severnyy Polyus-4 also began to observe a decrease of temperature with height in the tropopause.

A characteristic feature of the tropopause in mid-winter was a slowing down of the temperature drop with increasing height and a more rapid drop of temperature in the lower stratosphere. However, it was not possible to send up a radiosonde higher than 24 kilometers during mid-winter because of insufficient frost-resistance of the balloon casing; under low temperatures the balloons would burst much faster than in summer. In addition, the radiosondes themselves were not adapted to measuring temperatures below minus 70 degrees C.

The minimum temperature, recorded on 4 January 1956, was minus 81.2 degrees C, at a height of about 20 kilometers. Such a low temperature was recorded for the first time in the Arctic. During the winter of 1955-1956, similar temperatures in the lower stratosphere were observed many times at Severnyy Polyus-4 and also at Severnyy Polyus-5.

The difference between maximum and minimum temperatures recorded in the lower stratosphere in summer and winter equals 60 degrees C. Therefore, the greatest seasonal changes in the Central Arctic take place not in the lower levels of the atmosphere, but at considerable heights.

A temperature drop with increasing height in the lower stratosphere ceased to be observed in mid-March, as soon as this layer began to be exposed to sunlight at the end of the polar night. On 15 March 1956, beginning at a height of 14-15 kilometers, the temperature rose with height, but in the tropopause the gradual lowering of temperature with height, characteristic for winter, was still being observed.

An abrupt change in the temperature stratification, observed in the lower stratosphere at the end of winter, is caused to a considerable extent by the absorption of solar radiation by atmospheric ozone, a concentration of which reaches its maximum at a height of about 25 kilometers. In March the arctic atmosphere is richest in ozone.

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With the increasing height of the Sun, the temperature in the lower stratosphere continues to raise gradually. This warming up of the upper atmosphere in polar regions during mid-summer is probably more considerable than anywhere else on the Earth.

As is known, on the day of the summer solstice the daily sum of heat received from the Sun at the limits of the atmosphere above the North Pole equals 1,043 calories per square centimeter, whereas at the equator it is only 765 calories per square centimeter. In addition, the polar atmosphere contains the greatest amount of ozone, since as a result of low temperatures there is a long period of semidecomposition of ozone and only a small quantity of ozone is consumed for the oxidation of organic matter, especially dust, which is scarce in the atmosphere of polar countries.

The lower stratosphere in the region of the pole includes a heat zone. This causes a rise in isobaric surfaces and a formation of high-altitude anticyclones. The cyclonic circulation prevailing above the pole in the central and upper troposphere apparently reverses itself at very high altitudes (20-30 kilometers). In accordance with the diminishing height of the Sun, the lower stratosphere cools off and in place of a heat zone a high-altitude zone of cold is formed above the pole during the polar night. The radiation regime of the polar night causes a radical change in the temperature of the lower stratosphere. The rays of the Sun no longer irradiate the atmosphere in the central Arctic, and the atmosphere cools off through radiation by water vapors, ozone, and carbon dioxide.

In the winter, especially from December to February, an intense cold zone is formed above the pole. This causes an increase cyclonic circulation, which prevails in the central and upper troposphere, and the formation of a high (or high-altitude) cyclone.

In analyzing baric topography map sectors adjoining the North Pole, the data of pilot-balloon and radiosonde observations of wind at various heights were very helpful. High speeds of wind (150-200 kilometers per hour and more) usually occur in the upper troposphere at an altitude of 6-8 kilometers. At the same time, the speed of wind decreases abruptly with increasing height in the tropopause and lower stratosphere. Apparently, the intensity of baric formations above the level of the tropopause decreases considerably.

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The lower stratosphere of the Central Arctic contains a layer which is fairly favorable for flights, where the winds diminish in force, and there would probably be less danger of airplane overload due to stress caused by turbulence. However, during the winter, when a high cyclone retains great intensity, strong winds were not restricted to the upper troposphere, as usual, but were observed also at altitudes of 14 kilometers and more.

There is still much that remains unexplained regarding the structure of the tropopause and the lower stratosphere. For example, according to existing theories, at all latitudes of the Earth the temperature rises in the stratosphere, and at a height of about 50-55 kilometers the temperature reaches zero degrees C or even higher. It seems doubtful that this would apply to the atmosphere of the Central Arctic, or the Antarctic, which is not exposed to the Sun during the polar night, especially since during mid-winter there is a decrease in temperature with increasing height in the stratosphere, at least up to a height of 24 kilometers.

The lower atmosphere in the Central Arctic has a number of characteristic features, caused by the special nature of the underlying surface and of the radiation regime. A number of these peculiar features were recorded earlier by Ye. I. Tolstikov and K. I. Chukanin. Systematic observations at drift stations have offered great possibilities for research of this type.

The Severnyy Polyus-4 staff discovered that the lower 1-2 kilometers of the atmosphere represent a disturbed layer with a number of special strata and points in the field of temperature and the field of humidity. During a whole year, the layers of air in contact with the ice cool off thoroughly, and for that reason the temperature does not decrease with height, as is customary, but rises with height.

The inversions in April and May occurred, as a rule, in high-pressure zones in conjunction with clearing skies and light winds, and were caused by radiation cooling at the underlying surface. Inversions apparently are intensified by downward movements of air, developing under conditions of an anticyclone. In mid-summer, inversions were frequently caused by the displacement of warm air from southern latitudes. In July there was an instance when a temperature of about plus 10 degrees C was recorded at an altitude of several hundred meters, while the temperature near the ice surface was close to zero degrees C.

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In the immediate vicinity of the underlying surface, with increasing winds which cause a mixing of the air, and also with increasing cloudiness or under cover of fog, which causes a decrease in radiation, a breakup of the inversion occurs and for several hundred meters the temperature decreases with height, but higher up the inversion is retained. A layer with a similar temperature distribution is also formed as a result of the intrusion of colder air, and is often called a "cold film."

A considerable number of inversions were observed in May, when anti-cyclonic weather conditions and clear skies prevailed. In mid-summer, the number of inversions decreases noticeably; this is caused by the fact that the amount of heat from solar radiation increases sharply and warm air is transferred from southern latitudes. However, in connection with the frequent passage of fronts the number of instances of "cold film" increases; the major part of inversions began not at the ice surface but at a certain altitude. In the fall the number of inversions increases.

In the winter, when cloudless weather prevails and the radiation of the underlying surface increases sharply, the recurrence and intensity of inversions grow considerably; in November and December inversions were observed continuously. During the winter the vertical gradients in inversions reach 7-8 degrees per 100 meters. The breakup of very deep winter inversions in the layer adjoining the ice surface does not occur as easily and frequently as has been observed in summer, and it is caused mainly by the passage of cyclones.

Inversions are quite often accompanied by radiation fogs, especially in the summer when an intense melting of snow and ice takes place. The fog is preserved for long periods in the inversion layer, under conditions of slow diffusion. Stratified cloud formations usually occur also within the "cold film." In those cases when there is no intercepting layer above the cloud formations, i.e., an inversion or isotherm, the clouds disintegrate very quickly. Apparently, a diffusion of moisture into higher layers takes place. However, the stratified cloud formations within the inversion layer frequently do not have a sharply defined lower demarcation and change over into fog.

Fogs and low stratified clouds consist of minute supercooled water droplets; this is evident from the white rainbows which may be observed constantly when the Sun is low.

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During the cold season, when evaporation from the underlying surface in the Central Arctic is greatly reduced, the number of days with fog decreases considerably. A cover of stratified clouds is formed only in rare instances and usually dissolves very quickly.

The existence in the lower atmosphere of a current of moisture, coming from the direction of the underlying surface, under temperature conditions of minus 40 degrees C and lower, often results in the formation of ice crystals in the inversion zone adjoining the ice surface. Ice crystals were observed in this zone almost continuously during the winter.

The drift stations are providing new and extremely interesting material on the peculiar atmospheric processes in the Central Arctic. One of the most important tasks of research during the IGY is the study of the structure of the polar atmosphere at high altitudes. Improved high-altitude radiosondes and meteorological rockets are to be used for the study of the upper atmosphere. Radiosonde ascents into the stratosphere are particularly interesting during December and January, when the stratosphere is not exposed to the Sun. Another important task is the study of the distribution of ozone at high altitudes, and research on the extent and structure of frontal cloud formations, both with the help of airplanes and by radar methods. (Moscow, Priroda, No 12, Dec '57, pp 27-34)

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